Mount Rainier National Park

Sister Mountain Project

Stream Team: Benthic Bugs and Bioassessment

Overview	Students investigate the relative water quality of a stream by conducting a simulated bioassessment by sampling aquatic macroinvertebrates (represented by ordinary materials) in order to prepare for a real-life macroinvertebrate survey that will be conducted with the Nation Parks Aquatic Resources field team at one of Mount Rainier's streams, rivers, or lakes in order to assess the overall health of that body of water.
Grade Level	5-8
Objectives	• Students will investigate the role that aquatic macroinvertebrates play in determining water quality. • Students will simulate the process of rapid bioassessment of aquatic macroinvertebrates. • Students will collect, sort, classify, identify, analyze, and evaluate a sample of materials representing aquatic macroinvertebrates. • Students will determine a stream's water quality using a pollution tolerance index based on a sample of aquatic macroinvertebrates. • Students will compare the differences between the relative water quality of different samples.
Setting	Classroom
Timeframe	Preperation-30 minutes Activity-two 50 minute periods
Materials	✓ Copies of **Macroinvertebrate Identification Chart** student copy page (1 per group) ✓ Copies of **Macroinvertebrate Data Sheet I** student copy page (1 per group) ✓ Copies of **Macroinvertebrate Data Sheet II** student copy page (1 per group) ✓ Plastic tubs or storage bins for holding samples-dishpan size (3) ✓ Smaller plastic tubs or bowls-white (3) ✓ Aquarium nets-small, hand-held; can use turkey baster as well (3) ✓ Ice cube trays, petri dishes, or other sorting device (3) ✓ Calculators (3) ✓ Water to fill the 3 sample tubs with at least 4" of water with blue food coloring so students can not see the objects in the tub. Coloring options include powdered cocoa mix to simulate sediments, tea bags to darken the water, powdered fruit drink mix.

	✓ Small paper clips (100) ✓ Large paper clips (50) ✓ Six different sizes, shapes, or colors of beads (50 of each size/color/shape) ✓ Pennies or other coins (50) ✓ Thin rubber bands (50) ✓ Thick rubber bands (50)
Vocabulary	Bioassessment, Macroinvertebrate, Biodiversity, Benthic
Standards	6-8 LS2B Energy flows through an ecosystem from producers (plants) to consumers to decomposers. These relationships can be shown for specific populations in a food web. 6-8 LS2D Ecosystems are continuously changing. Causes of these changes include nonliving factors such as the amount of light, range of temperatures, and availability of water, as well as living factors such as the disappearance of different species through disease, predation, habitat destruction and overuse of resources or the introduction of new species. 6-8 SYSA Any system may be thought of as containing subsystems and as being a subsystem of a larger system 6-8 SYSB The boundaries of a system can be drawn differently depending on the features of the system being investigated, the size of the system, and the purpose of the investigation. 6-8 SYSF The natural and designed world is complex; it is too large and complicated to investigate and comprehend all at once. Scientists and students learn to define small portions for the convenience of investigation. The units of investigation can be referred to as "systems." ?6-8 INQA —Question— Scientific inquiry involves asking and answering questions and comparing the answer with what scientists already know about the world. 6-8 INQC —Investigate— Collecting, analyzing, and displaying data are essential aspects of all investigations. 6-8 INQE —Model— Models are used to represent objects, events, systems, and processes. Models can be used to test hypotheses and better understand phenomena, but they have limitations.

	6-8 INQG —Communicate Clearly— Scientific reports should enable another investigator to repeat the study to check the results 6-8 INQI —Consider Ethics— Scientists and engineers have ethical codes governing animal experiments, research in natural ecosystems, and studies that involve human subjects.
Background	Mount Rainier is home to hundreds of alpine lakes, streams and rivers. With so much water and so little resources to determine the health of these bodies of water scientists have devised a cleaver way to assess the health of our parks water. According to park field biologists, "The most direct and effective measure of the integrity of a water body is the status of its living systems." One important way to determine the status of water's living systems is through biological assessment (bioassessment), which is the use of biological surveys and other direct measurements of living systems within a watershed. Aquatic macroinvertebrates (animals without backbones that live in aquatic environments and are large enough to be seen without the aid of a microscope or other magnification) are commonly monitored and are the basis of this activity. Macroinvertebrates are valuable indicators of the health of aquatic environments in part because they are benthic, meaning they are typically found on the bottom of a stream or lake and do not move over large distances. Therefore, they cannot easily or quickly migrate away from pollution or environmental stress. Because different species of macroinvertebrates react differently to environmental stressors like pollution, sediment loading, and habitat changes, quantifying the diversity and density of different macroinvertebrates at a given site can create a picture of the environmental conditions of that body of water. If exposed to an environmental stressor (e.g., pollution, warming due to low flows, low dissolved oxygen due to algal blooms, etc.), those macroinvertebrates that are intolerant to that stress may perish. Tolerant macroinvertebrates often inhabit the spaces left by the intolerant organisms, creating an entirely different population of organisms. For example, an unimpacted body of water will typically contain a majority of macroinvertebrates that are intolerant of environmental stressors, such as mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera). A body of water that has undergone environmental stress may contain a majority of macroinvertebrates that are tolerant of these conditions such as leeches (hirudinea), tubifex worms (Tubifex sp.), and pouch snails (Gastropoda). Bioassessments of macroinvertebrates are particularly helpful to biologists and others trying to determine the health of a river or stream. Bioassessment of macroinvertebrates is a procedure that uses inexpensive equipment, is scientifically valid if done correctly, and can be conducted by students. Bioassessments can provide benchmarks to which other waters may be compared

	and can also be used to define rehabilitation goals and to monitor trends. Trend monitoring is a common application of bioassessment by student groups and others involved in water quality monitoring. Collecting, identifying, and quantifying macroinvertebrates are the initial steps in a bioassessment. The next step involves using formulas to calculate the relative water quality based on the diversity and quantity of the sampled organisms. These formulas, called metrics, relate the numerical diversity and density of organisms to a water quality rating. The most common metrics are the EPT/Midge Ration and the Pollution Tolerance Index. The EPT/Midge Ratio metric compares the total number of intolerant organisms, specifically the E.P.T.-**E**phemeropterans (mayflies), **P**lecopterans (stoneflies), and **T**richopterans (caddisflies)-with the total number of tolerant organisms, specifically Chironomids (midges). Typically the higher number of intolerant organisms, the better the water quality. The Pollution Tolerance Index assigns a numerical value to each macroinvertebrate order, with the higher numbers assigned to pollution intolerant organisms and decreasing numbers assigned to increasingly pollution tolerant organisms. The scores are totaled and compared with a water quality assessment scale to yield a relative water quality rating for the sample. To gather the best quality and most usable data, the Environmental Protection Agency (EPA) recommends that biological sampling of macroinvertebrates be conducted in ways that minimize year-to-year variability. To accomplish this, biologists tend to sample for at least one week during the same season(s) each year. Additionally, sampling is conducted when sites are easily accessible and the number of organisms high. This usually occurs in the spring after the ice has broken and late-stage larvae are present, or in the fall when organisms are more mature. While bioassessments are extremely important in and of themselves, they are most useful when combined with chemical and habitat assessments. Biosurvey techniques, such as the Rapid Bioassessment Protocols are best used for detecting aquatic life impairments and assessing their relative severity. Once impairment is detected, however, additional ecological data, such as chemical and biological (toxicity) testing is helpful to identify the causative agents, its source and to implement appropriate mitigation.
Procedure	**Warm Up** 1. Ask students to define the term "aquatic macroinvertebrate" (invertebrates that live in streams, rivers, lakes, or ponds that are large enough to be seen without the aid of a microscope or other magnification). 2. Have them list examples of aquatic macroinvertebrates (e.g., leeches

mayflies, snails, dragonflies, etc.), and their role in the food web of a stream.

3. Divide students into three groups and distribute copies of the **Macroinvertebrate Identification Chart** to each group. Instruct them to complete the middle (Looks Like) column of this sheet by researching aquatic macroinvertebrates on the Internet, in riled guides. www.benthos.org is a good site.
4. Briefly explain to the students that aquatic macroinvertebrates are used as indicators of the relative health of a stream, and that the common form of sampling them is called bioassessment, which they will conduct in this activity.

The Activity

1. Inform students that they will be simulating a bioassessment of a stream using ordinary objects to represent macroinvertebrates.
2. Set up three sets of collecting stations (see illustration that follows), each containing the following: stream sampling site (see directions in Step 2), collection bucket, sorting tray, the **Macroinvertebrate Identification Chart**, and **Macroinvertebrate Data Sheets I and II.**

Stream 1: Stream Sampling Site (Collect for 20 seconds) →	Collection Bucket (dump net) →	Sorting Trays (sort/identify) →	Data Sheet I (tabulate) →	Data Sheet II (calculate) →	(Analyze)
Stream 2: Stream Sampling Site (Collect for 20 seconds) →	Collection Bucket (dump net) →	Sorting Trays (sort/identify) →	Data Sheet I (tabulate) →	Data Sheet II (calculate) →	(Analyze)
Stream 3: Stream Sampling Site (Collect for 20 seconds) →	Collection Bucket (dump net) →	Sorting Trays (sort/identify) →	Data Sheet I (tabulate) →	Data Sheet II (calculate) →	(Analyze)

3. For the stream sampling sites: fill three large plastic storage bins with

four inches of water and label them stream 1, 2, and 3. Add food coloring or cocoa for sediments to simulate degraded water if you like!

4. Place objects representing macroinvertebrates in the three tubs according to the following chart:

Macroinvertebrate	**Represented by:**	**Number of Items per Sample**			**Total Items**
		Stream Sample 1	**Stream Sample 2**	**Stream Sample 3**	
Mayflies	Yellow beads	35	15	0	50 beads
Stoneflies	Small paper clips	65	35	0	100 clips
Caddisflies	Blue beads	30	20	0	50 beads
Dobsonflies	Large paper clips	30	20	0	50 clips
Midges	Red beads	0	20	30	50 beads
Craneflies	White beads	25	13	12	50 beads
Dragonflies	Green beads	20	20	10	50 beads
Scuds	Black beads	5	15	30	50 beads
Pouch Snails	Pennies	0	15	35	50 pennies
Tubifex Worms	Thin rubber bands	0	15	35	50 bands
Leeches	Thick rubber bands	0	15	35	50 bands

	5. Divide students into three groups. Assign students within each group to one of the following five tasks: stream sampling, sorting at the collection bucket, counting/recording at **Macroinvertebrate Data Sheet I**, and calculating/evaluating at **Macroinveretbrate Data Sheet II**.
	6. Instruct students to simulate a rapid bioassessment at their stream sampling site as follows:
	    a. Using an aquarium net, the students at the site have twenty seconds to collect as many macroinvertebrates (paper clips, bead, etc.) from the stream as possible. They should place the macroinvertebrates in the collection bucket.
	    b. Students at the collection bucket then sort the collected macroinvertebrates into like categories based on the **Macroinvertebrate Identification Sheet** and place them in the ice cube tray or cups. For example, they should place all the mayflies into the cube, caddisflies into one cube, caddisflies, into another etc.
	    c. The students using the **Macroinvertebrate Data Sheet I** tabulate the sorting results onto the data sheet and calculate the percent composition of each macroinvertebrate in the stream site.
	    d. The students with **Macroinvertebrate Data Sheet II** use the data from **Data Sheet I** to complete the Pollution Tolerance Index to determine their Water Quality Assessment score for their stream sample.
	7. Have students compare their results with the other groups. What were the similarities and differences between the three sites? Which stream had the highest level of water quality? The lowest?
	
	Wrap Up
	Have students write a paragraph that describes their stream bases on the macroinvertebrate sample they collected. If they sampled an impaired stream they should describe the habitat, address possible pollution sources, and give other pertinent details. Allow them to be creative.
	
	Ask students what they think of this type of scientific sampling process. Do students feel that they could use this same process to perform a bioassessement in an actual stream? Did their samples accurately reflect the population of invertebrates in their stream? How do they know? Ask students to brainstorm how the process could be modified to increase accuracy (e.g., conduct the sampling three times for each stream and compare or average the results)?
	
	Have them identify positive and negative aspects of this type of sampling. For example, do they believe that they netted larger insects more easily than smaller insects? Can such biased sampling occur in an actual rapid bioassessment of

	invertebrates?
Suggested Assessment	Have students: • Investigate the role that aquatic macroinvertebrates ply in determining water quality (**Warm Up**) • Simulate the process of rapid bioassessment of aquatic macroinvertebrates (**Steps 5 and 6**). • Collect, sort, classify, identify, analyze and evaluate a sample of materials representing aquatic macroinvertebrates (**Step 6**). • Determine a stream's water quality using a pollution tolerance index based on a sample of aquatic macroinvertebrates (**Step 6**). • Compare the differences between the relative water quality of different samples (**Step 7**). • Interpret water quality data to develop a description of a stream (**Wrap Up**).
Adaptations	If access to streams and lakes are not possible conduct the bioassessement with adult insects instead. Contact a local entomologist in your area to get a list of species and their pollution tolerance.
Extensions	Have the students conduct an actual bioassessment with Mount Rainier National Park field biologists! Please refer to **Citizen Science** activity for complete details on how to set up this real-life field investigation where your students collect data that will be used by the Park Service.
References/ Resources	Healthy Water, Healthy People: Water Quality Educators Guide. Bozeman, MT: Project WET International Foundation, 2006. Print Project WET: Curriculum & Activity. Bozeman, MT: Project WET International Foundation, 2006. Print Project Learning Tree: Pre K-8 Environmental Education Activity Guide. Washington, D.C.: American Forest Foundation Center for Environmental Learning, 2009. Print Project WILD: K-12 Curriculum & Activity Guide. Houston, TX: Project WILD National Office, 2008. Print